

and possibly coincident with, that along which the Jurassic and Liassic strata thin out very rapidly in south-east Yorkshire, and passing thence towards the Cumberland lakes; (e) a line the general direction of which coincides with that of the Palæozoic ridge between London and the South Wales coal-field.

The following Paper was read:—

I. “Experiments on the Nutritive Value of Wheat Meal.” By  
A. WYNTER BLYTH. Communicated by Dr. LAUDER  
BRUNTON, F.R.S. Received March 30, 1889.

A physician, who may be designated as A, undertook to live for twenty-eight days on distilled water and whole meal. Each day a certain quantity of the meal was ground by himself, weighed, and made either into cakes or porridge by means of distilled water.

The excreta were forwarded to me for analysis.

The experiment may be divided into three stages:—(1) A period of eight days, during which the insufficient quantity of 16 ozs. (453·59 grams) of whole meal was taken; (2) a period of fourteen days, during which 20 ozs. (566·98 grams) of whole meal were taken; (3) a period of seven days during which 28 ozs. (793·77 grams) of whole meal were taken.

*General Physiological Effects.*

The condition of A was carefully tested by Mr. Randall at Mr. Francis Galton’s laboratory, before and during these periods.

Condition before the experiment:—

|                                                       |              |
|-------------------------------------------------------|--------------|
| Weight in clothing .....                              | 129 lbs.     |
| Strength of squeeze (right hand) .....                | 67 „         |
| „ (left hand).....                                    | 60 „         |
| Breathing capacity .....                              | 198 cub. in. |
| Distance of reading diamond numerals (right eye)..... | 9 inches.    |
| Distance of reading diamond numerals (left eye) ..... | 7 „          |
| Snellen’s type, read at 20 feet distance.....         | D 60         |
| Highest audible note (by whistle) .....               | 19,000 vib.  |
| Reaction time (sound) .....                           | 15*          |
| „ (sight) .....                                       | 15*          |
| Error in dividing wire in half .....                  | 0 p. c.      |
| „ „ in thirds.....                                    | 0 p. c.      |
| Error in degrees in estimating angle 90° .....        | 0°           |
| „ „ „ 60° .....                                       | 11°          |

\* Reaction time for sound and sight in hundredths of a second.

At the end of the first period, during which the insufficient quantity of 16 ozs. was taken, there was a loss in weight of 7 lbs., the breathing capacity seemed a little increased, but the tests showed no other marked deviation from the above. During the second period, in which the meal was increased to 20 ozs., there was a farther loss of 3 lbs. During the third period, when 28 ozs. were taken, this loss of weight ceased and a slight gain was recorded.

During the whole twenty-eight days, A suffered, according to his own account, but trifling inconvenience: the bodily functions were regularly performed, the mental capacity unaltered; there was a marked absence of indigestion, the sleep was sound, and there was no deterioration of muscular power. On the other hand there was a marked decrease of sexual power as well as desire. The appearance of A during and at the end of the experiment was not that of perfect health. The features were pinched; there was slight anæmia.

The measurements and tests as determined in Mr. Francis Galton's laboratory were as follows:—

|                                                         | 1st period.  | 2nd period.  | 3rd period.  | Last day of experiment. |
|---------------------------------------------------------|--------------|--------------|--------------|-------------------------|
| Weight in clothing, . . .                               | 122 lbs.     | 119 lbs.     | 120 lbs.     | 120½ lbs.               |
| Strength of squeeze, right hand . . . . .               | 76 "         | 65 "         | 74 "         | 73 "                    |
| Ditto, left hand . . . . .                              | 68 "         | 62 "         | 68 "         | 65 "                    |
| Breathing capacity, . . .                               | 203 cub. in. | 190 cub. in. | 198 cub. in. | 189 cub. in.            |
| Distance of reading (diamond type), right eye . . . . . | 9 in.        | 10 in.       | 10 in.       | 9 in.                   |
| Ditto, left eye . . . . .                               | 10 "         | 9 "          | 9 "          | 8 "                     |
| Snellen's type, read at 20 feet distance . . . . .      | D 60         | D 60         | D 60         | D 60                    |
| Highest audible note (whistle) . . . . .                | 19,000 vib.  | 19,000 vib.  | 19,000 vib.  | 19,000 vib.             |
| Reaction time (sound) . .                               | 15*          | 16*          | 10*          | 13*                     |
| " (sight) . . . . .                                     | 13*          | 13*          | 10*          | 10*                     |
| Error in dividing wire in half . . . . .                | 0 p. c.      | 0 p. c.      | 0 p. c.      |                         |
| Ditto in thirds, . . . . .                              | 1 "          | 1 "          | 1 "          |                         |
| Error in estimating angle 90° . . . . .                 | 1            | 1 "          | 0            |                         |
| Ditto 60° . . . . .                                     | 7            | 10           | 10           |                         |

#### *Analysis of Income and Output.*

The whole meal was analysed by ordinary methods, the nitrogen being determined by Kjeldahl's process, the fat in a Soxhlet's apparatus by exhaustion with petroleum ether. The fæces were passed into strong redistilled methyl alcohol, dried, powdered and treated simi-

\* Reaction time for sound and sight in hundredths of a second.

larly to the whole meal. The urine was also treated by Kjeldahl for nitrogen, the solid residue by evaporating several 5 c.c. in platinum dishes to dryness, and the phosphoric acid by the volumetric uranium method. The following tables give the results :—

First Period. Insufficient Supply of Whole Meal.

|                       | Whole meal ingested daily. | Daily excretion. |        |         |
|-----------------------|----------------------------|------------------|--------|---------|
|                       |                            | Fæces.           | Urine. |         |
|                       | grams.                     | grams.           | grams. |         |
| Dry substance.....    | 392·35                     | 40·4             | 27·62  | —324·33 |
| Nitrogen .....        | 9·07                       | 1·72             | 9·57   | +2·22   |
| Fat .....             | 8·25                       | 2·52             | ..     | —5·73   |
| Ash .....             | 6·94                       | 3·88             | 4·38   | +1·32   |
| Phosphoric acid ..... | 3·17                       | 1·5              | 2·03   | +0·36   |
| Sulphuric acid .....  | 0·27                       | 0·05             | 1·46   | +1·24   |
| Chlorine .....        | ..                         | ..               | 1·05   | +1·05   |

The table shows that 82·6 per cent. of the dry substance was assimilated, of the fat 69 per cent. disappeared, 2·22 grams of nitrogen were excreted in excess of that ingested, there was (practically) phosphoric acid equilibrium, there were more salts excreted than taken in, and there was excretion of sulphur and chlorine, although the water taken as a drink and mixed with the food was distilled, and only a small quantity of unoxidised sulphur could be detected in the flour.

Second Period. Barely sufficient Ingestion of Whole Meal.

|                       | Whole meal ingested daily. | Daily excretion. |        |         |
|-----------------------|----------------------------|------------------|--------|---------|
|                       |                            | Fæces.           | Urine. |         |
|                       | grams.                     | grams.           | grams. |         |
| Dry substance.....    | 490·44                     | 47·5             | 29·16  | —413·78 |
| Nitrogen .....        | 11·34                      | 2·02             | 9·75   | +0·43   |
| Fat .....             | 10·31                      | 2·29             | ..     | —8·02   |
| Ash .....             | 8·67                       | 3·7              | 3·99   | —0·98   |
| Phosphoric acid ..... | 3·97                       | 1·91             | 1·95   | —0·11   |
| Sulphuric acid .....  | 0·34                       | 0·03             | 1·71   | +1·40   |
| Chlorine .....        | ..                         | ..               | 0·88   | +0·88   |

84·3 per cent. was therefore digested of the dry substance, 77·7 per cent. of the fat had disappeared, there was (practically) nitrogenous

and phosphoric acid equilibrium, and some small retention of salts. There was a daily excretion of sulphur and chlorine, the latter in small amount only.

Third Period. A sufficient Supply of Whole Meal. Arrest of Loss of Weight.

|                       | Whole meal ingested. | Excretion. |        |         |
|-----------------------|----------------------|------------|--------|---------|
|                       |                      | Fæces.     | Urine. |         |
| Dry substance .....   | 686·62               | 78·4       | 33·60  | —574·62 |
| Nitrogen .....        | 15·87                | 2·6        | 8·39   | —4·88   |
| Fat .....             | 14·44                | 9·24       | ..     | —5·20   |
| Ash .....             | 12·04                | 7·9        | 3·28   | —0·86   |
| Phosphoric acid ..... | 5·59                 | 3·5        | 1·93   | —0·16   |
| Sulphuric acid .....  | 0·47                 | 0·17       | 1·82   | +1·52   |
| Chlorine .....        | ..                   | ..         | 1·06   | +1·06   |

During this last period there was retention of nitrogen. The phosphates were pretty well balanced, that is, ingestion was nearly equal to excretion, 83·6 per cent. of the total dry substance was digested, but only 36 per cent. of the fat. It is to be noted that there was an undiminished urinary output of chlorine and sulphur.

The constant undiminished excretion of sulphuric acid as sulphate by the urine and a small quantity of unoxidised sulphur by the intestinal canal, although only traces were found in the flour itself, rendered it desirable that there should be a control experiment upon some other person. Accordingly, an Oxford graduate, upon whom every reliance could be placed, undertook to live for one week upon whole meal and distilled water. This gentleman will be referred to as O.

O lived a sedentary life, was of a slight build, and weighed 137 lbs. at the commencement of the experiment. He took also each day a measured quantity of olive oil, the oil being mixed with the whole meal and baked with it. The quantity of whole meal taken daily varied from 16—22 ozs. The solid excreta of the last three days only were collected for analysis, and the urine of the last two days.

## General Results of the Ingestion of Whole Meal by O.

|                       | Whole meal ingested. | Excretion. |        |           |
|-----------------------|----------------------|------------|--------|-----------|
|                       |                      | Fæces.     | Urine. |           |
| Dry substance .....   | 497·53               | 28·88      | 33·13  | * -463·03 |
| Nitrogen .....        | 11·33                | 1·18       | 10·30  | +0·15     |
| Fat .....             | 10·31                | 2·58       | ..     | } -35·24  |
| (Olive oil) .....     | (27·51)              | ..         | ..     |           |
| Ash .....             | 8·67                 | 3·35       | 3·67   | -1·65     |
| Sulphuric acid .....  | 0·34                 | ..         | 0·91   | +0·57     |
| Phosphoric acid ..... | 3·05                 | 1·42       | 1·72   | +0·09     |
| Chlorine, .....       | ..                   | ..         | 0·07   | +0·07     |

O, therefore, digested 88·1 per cent. of dry substance ingested; 93 per cent. of the fat disappeared. There was (practically) nitrogenous and phosphoric acid equilibrium; there was some retention of salts, perhaps to be attributed to the small quantity of liquid O drank. Sulphur was excreted, although only traces were ingested, and the excretion of chlorine was small.

At the end of the experiment O was in good health. He had lost a little in weight—1·25 lbs.

The importance of obtaining exact information of the nutritive powers of bread as the basis of ordinary diet need scarcely be accentuated. The quantities of whole meal consumed *per diem* were, it is obvious, deficient in nitrogen, in fat, and in salts. Both of the gentlemen who undertook the experiment lived an ordinary town life, that is, they daily took moderate exercise, but their pursuits involved no manual or hard labour, and therefore must be classed as sedentary; but a less supply than 18 grams of nitrogen and 5 grams of fat would not be likely to keep either of them for a long period in the highest health. The excretion of sulphate by the urine and of unoxidised sulphur by the bowel is interesting and demands still further experiment; considering that sulphur is an essential component of albumen, too little attention has hitherto been paid to its study as a food, but it is obvious that once it is accepted that the external supplies of sulphur were cut off, the sulphur found must have been derived from sulphur stores in the body, with possibly a trifling amount condensed in the lung from breathing London air.

If the excretion by the bowel be considered waste, then on an average 15·6 per cent. of the total nitrogen in the bread or whole meal is not in an assimilable form; about 37 per cent. of the fat is also not digested, and 51·8 per cent. of the ash also passes away.

\* Obtained by subtracting 497·53 + 27·51 (olive oil) from united residue of fæces and urine.

The Society then adjourned over the Easter Recess to Thursday, May 2nd.

*Presents, April 11, 1889.*

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